Digital Creativity

ISSN: 1462-6268 (Print) 1744-3806 (Online) Journal homepage: http://www.tandfonline.com/loi/ndcr20

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To cite this article: Nick Lambert (2012) Domes and creativity: a historical exploration, Digital Creativity, 23:1, 5-29, DOI: 10.1080/14626268.2012.664821

To link to this article: https://doi.org/10.1080/14626268.2012.664821

Digital Creativity
2012, Vol. 23, No. 1, pp. 5–29

Domes and creativity: a historical exploration

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Abstract

This article examines the deeper history of the dome-as-venue and considers what contemporary fulldome artists could learn from the past. It also looks at antecedents found in the work of the artists who sought to unify sound and image in special performance spaces, and how their holistic conception of 'art' involving all the senses might be applied to fulldome work.

Keywords: immersive environments, projection, domes, virtual reality

1 Introduction

In 1964, computer graphics pioneer Ivan Sutherland envisioned a completely realistic and all-encompassing virtual space that he termed the 'Ultimate Display' and later tried to build an early realisation at MIT as the 'Sword of Damocles' (Sutherland 1965). Since then, a variety of immersive technologies have striven to take the concept of Virtual Reality (VR) forward, but after the false dawn of VR hardware as a widespread computer interface in the early 1990s, it remains an aspiration amongst computer graphics developers.

This is not to deny that headsets and virtual environments have found a niche in specialist research situations, and in practical applications like visualising geological datasets or training pilots, but Sutherland's vision of a wholly immersive space has yet to come about. Though many people participate in online virtual worlds, they do so through the medium of the standard computer monitor, even though these are the very places where a VR-type interface would work best. However a significant body of theory concerning VR has appeared in the meantime, and continues to grow.

Meanwhile in the cinema, the old technology of stereoscopy has been revived through high-resolution digital production and projection and is now arguably a mass-market phenomenon, even if its domestic offshoots have yet to make a significant impact. Various immersive image technologies are challenging the century-old dominance of the flat cinematic screen and its later descendents, television and computer monitors. Of

ISSN 1462-6268
http://dx.doi.org/10.1080/14626268.2012.664821
http://www.tandfonline.com
Routledge
Taylor & Francis Group

these, fulldome is emerging as a significant new medium.

2 A brief history of dome projection

The history of fulldome is closely tied to the scientific milieu that produced the first planetaria with star projectors in Germany around 1924 (Chartrand 1973) There was a worldwide programme of planetaria-building from the late 1920s onwards, and experiments with film projection in domes followed in the 1930s. The OMNIMAX, often called IMAX Dome, is a variant of the IMAX large-format film projector developed initially for the San Diego Hall of Science planetarium dome around 1970; however, this is not a true fulldome as the projection only fills the forward part of the screen. The advent of video projectors led to the first specialised example for dome projection, the Digistar I, from Evans and Sutherland around 1983, which marked the entrance of dome projection into the digital medium.

The evolution of digital projectors led to smaller but more powerful units, and the demand for inflatable portable planetaria resulted in the adaptation of off-the-shelf projectors for domes. There was a growth in the demand for small- and medium-sized fisheye lens projectors during the 1990s, and the market was dominated by turnkey vendors until companies such as Elumenati developed even lower-cost solutions that made the hardware and software more affordable. Dome systems began appearing in non-traditional spaces such as galleries and outdoor concerts from the early 2000s. One notable instance of this was the Bok Globule at Burning Man in 2004, using David McConville's projection system and an inflatable dome at the desert festival (Davis 2004).

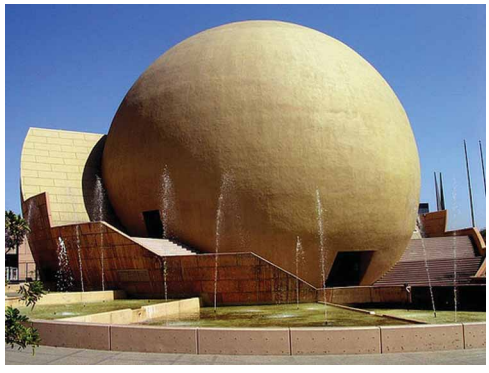

Figure 1. Omnimax Cinema in Tijuana, Baja California, Mexico.
Source: El Randy, 3 April 2006, http://en.wikipedia.org/wiki/File:Cecut.jpg. (By permission)

Around 2004, the Australian visualisation researcher Dr Paul Bourke conceived a novel method of dome projection using software distortion and a curved mirror in place of the expensive fisheye lens, enabling a wider range of projectors to be used in domes (Bourke 2005). He also distributed his method open-source, and installed a number of his systems in Australia, South-East Asia and elsewhere. This alternative approach further expanded the audience for dome production and enabled even more artists and experimenters to access a technology which had hitherto been the province of large educational and scientific institutions.

The development of astronomical domes and the subsequent evolution of the fulldome medium has been chronicled by David McConville of Elumenati (e.g. McConville 2007). Several universities in the USA, UK and Germany have developed fulldome animation courses, and organisations such as IMERSA and UK Fulldome have come together to represent producers and artists in the field.

3 Fulldome art

My own introduction to this area came as the result of a search for an appropriately scaled immersive system that could be used in a collaborative art project, *Music of the Spheres* (2006–2011). Having examined most varieties of VR, stereoscopy and exotic projection formats that were available around 2006, I eventually arrived at domes through a process of elimination. Factors such as portability, cost, robustness and software production processes all converged on the inflatable dome projection system as the obvious

medium for the work I was developing at the time. Since then, I have been gradually introduced to the community of fulldome developers and artists, and have become intrigued by the special properties of this emerging area.

I began working on *Music of the Spheres* with the artist and poet Jeff Rees in 2004. In its original form, it was to have been a computer-controlled mechanical installation inside a large warehouse-type space with physical spheres moving along a system of trackways in the roof. Given its size and complexity, I began looking at ways of scaling it down in order to develop it further.

Having looked at virtualising the sound system using Paul Gillieron's Ambisonics system, I proposed making the whole work into a virtual environment. I examined various strategies including CAVEs, head-tracking displays, stereoscopic and curved projection screens. Eventually I lighted on the emerging area of fulldome projection, to make use of near-360-degree projection inside a dome. (Lambert and Rees 2007)

The dome's principal attraction was its simulation of architectural space. Unlike the CAVE or contemporary stereoscopic films, dome projection produces an all-encompassing image that creates a convincing sense of height. However, the difficulties of producing a convincing dome projection with the technologies available on our budget meant that I had to investigate the cheapest possible software and develop some expertise in rendering images for a dome.

I came to understand some of the complexities of dome animation thanks to the work of Paul Bourke. As a visual researcher, Bourke was involved in developing portable planetaria for teaching astronomy to a wide range of groups and wanted to create a powerful open-source projection system that would address problems he felt affected the commercial systems then available. He provided an alternative to fisheye projection by using widely available convex mirrors to throw a projected image from the rear of the dome. He also produced software to correctly distort the image for this type of projection, enabling complete systems to be built around his concept. Most importantly, he then made this dome documentation freely available via his website to understand the mechanics of dome projection and how to build virtual environments to render images for this format.

In terms of making the images suitable for the dome, a wholly different approach to framing and scene constructing was necessary. As seen here, the dome can be inscribed on a flat surface as a circle within a square, with the centre as the apex of the dome and the top edge as the front of the dome. This means that the virtual camera that records the 3-D scene cannot focus on objects in the traditional way: instead objects move above and around it, and can move higher or lower in relation to the apex of the dome. With the possibility of action happening to the left and right of the audience and behind their heads as well, action has to be choreographed to avoid too much clutter, or a sense of motion sickness if the camera pans too fast, as the entire dome will seem to move. Obviously movement can be used effectively but some dome animations move camera position too quickly and—deliberately or not—end up disorienting the audience.

One of the central problems with dome projection is that until the image is actually seen within a dome, it cannot be properly assessed by the artist. All views on a flat surface are naturally distorted representations, although certain viewpoints can be simulated (see below). Apart from a brief trial inside an inflatable astronomy dome using a home-built apparatus, I never had a chance to preview *Music of the Spheres* in a dome environment until our recent showing at Fulldome UK 2011. In the interim, I looked for alternatives that could give me a sense of the dome space but made use of existing technologies and flat surfaces.

Following the first screening of *Music of the Spheres* at the Birmingham Thinktank as part of the UK Fulldome Festival 2011, I have become a participant in the group Fulldome UK which seeks to enable new approaches and activities in the dome. This issue of *Digital Creativity* is also an outcome of that process, which I hope will introduce dome projection to a wider audience of artists and other practitioners.

Digital Creativity, Vol. 23, No. 1

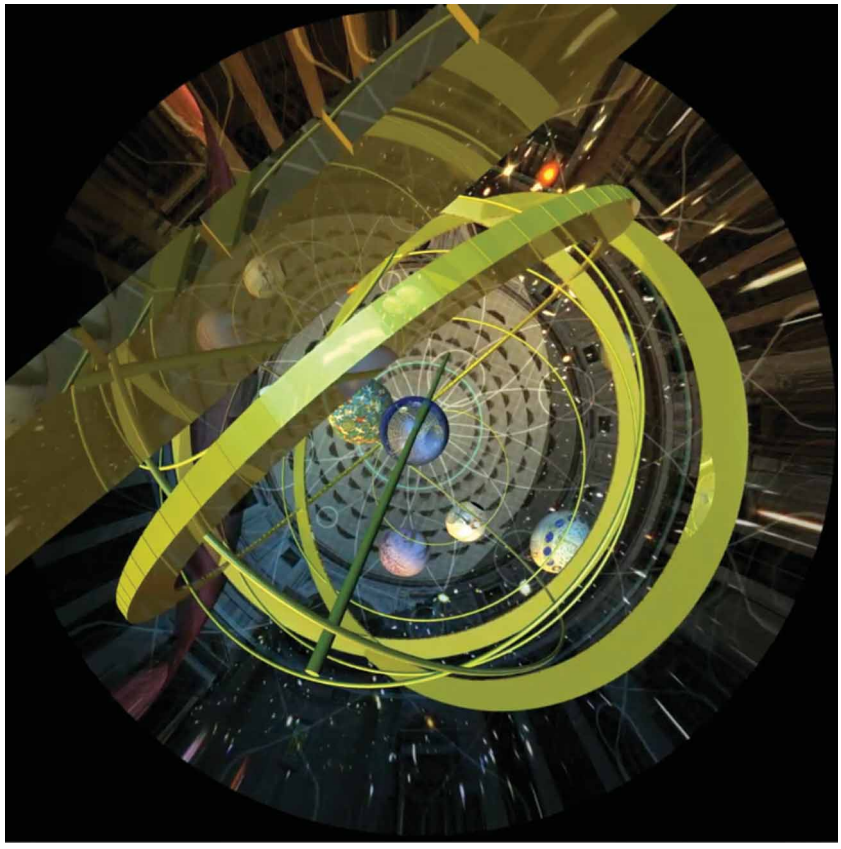

Figure 2. *Music of the Spheres* (2011), Jeff Rees and Nick Lambert (image reproduced with permission).

4 The fulldome experience

We are so conditioned to the screen format as a flat rectilinear surface that seeing images on the interior of a large dome can be an astounding, if disorienting, experience. The Thinktank Planetarium in Birmingham, for instance, has a diameter of 10 metres and seats seventy people in raked cinema-style seating, with the dome being tilted slightly towards the front. Six 1400x1050 projectors produce a merged image of 3200x3200 pixels across the surface of the dome, the system being controlled by Evans and Sutherland's Digistar 3 server (Anon 2011). The apex of the dome is around 6 metres above the middle seats, about the same height as a three-storey building.

The digital dome is the successor to the dedicated analogue star projectors that were first developed by Walter Bauersfeld for Carl Zeiss in 1923, the culmination of a project he had begun with Dr Max Wolf before the First World War (Anon, Zeiss). The Zeiss Model I Planetarium was a geodesic dome on top of the Zeiss factory at Jena; this was followed by an installation at the Deutsches Museum that opened in October 1923 and quickly became known as the 'wonder of Jena'. Subsequently planetaria began to be constructed around the world and entranced the first viewers of this spectacle in the 1920s:

> *It is the unanimous testimony of all who have visited these planetaria that in them has been achieved a means of instruction and entertainment of superlative merit. . . . It is a school, a theatre, a cinema in one . . . a drama with the celestial bodies as actors (Anon 1929, p. 137).*

Figure 3. Paul Grimmer's work *Continuum*, shown at the Centre for Life Planetarium in Newcastle, which has a similar Digistar setup to that in Birmingham.
Source: Paul Grimmer *Continuum* (2010), (Image: Colin Davison – reproduced with permission).

However the starry sky is, in one sense, two dimensional because it appears as a net of bright points suspended far off. One of the pioneers of light art, Thomas Wilfred, considered that the motion of the stars, and the Pythagorean notion of 'the music of the spheres' was the origin of subsequent forms of art using light and sound:

> *The majestic rhythm of heavenly bodies moving in their orbits appeared to [Pythagoras] as cosmic harmony, a vast rhythmic sequence of visual beauty—the music of the spheres. Here we have the first clear conception of a potential aesthetic language of form, color and motion in their purest manifestation—apart from earthly phenomena and the human body—and precisely the foundation upon which lumia [abstract animation] rests (Wilfred 1947, p. 247).*

When the dome projection changes to other visual material, such as the documentary *Stars of the Pharaohs* (Evans and Sutherland, 2004) that combines 3-D visualisations of Egyptian temples with camera footage and astronomical skies, the spatial qualities of this medium make their full impact. With a unified image appearing above and behind the viewer as well as in front, the journey through the columns of the Valley of the Kings places one in the midst of the scene instead of looking at it through an aperture. It is the height dimension that provides the unique quality of the fulldome medium. It also gives a monumental aspect to the concept of 'cyberspace' as articulated by Paul C. Adams:

> *In a word, the metaphor of cyberspace is about disembodiment. . . . In an interaction-defined space, up and down, inside and out, here and there take on particular meanings; vision ceases to be structured by the horizon and Cartesian geometry; movement shifts from a two- or three-dimensional space to a multidimensional space; phenomena in distant places are frequently connected instantaneously. The most similar conceptions of space are those associated with quantum theory and magic (Adams 1997, p. 164).*

In one sense, the dome manifests some of these qualities through hyper-realistic 3-D imagery, especially when using the all-too-common trope of a 'ride

Digital Creativity, Vol. 23, No. 1

Figure 4. The first Zeiss planetarium, Jena, 1923 (Photo: Carl Zeiss – reproduced with permission).
Source: Photo: Carl Zeiss. http://www.zeiss.de/C125679B0029303C/EmbedTitelIntern/WusstenSie_57/$File/WusstenSiedass_57_DL.jpg.

through the cosmos' for a scientific documentary. However, the dome can also be a space for abstract imagery too, and many fulldome artists take advantage of the multidimensional aspects by filling the dome surface with constantly changing patterns and fragmented views in multiple angles.

A key example of this, and one of the first dome artworks I saw, is *Celestial Mechanics* by D. Scott Hessels and Gabriel Dunne. This looks at the modern night sky in terms of flightpaths at different altitudes, starting just above the ground and continuing up beyond the atmosphere, taking in helicopters, airliners, weather balloons and ultimately satellites. It uses streams of data to create complex webs of flightpaths, but although the concept can be viewed as a 'flat' projection, it is designed for the dome space and can only be understood when viewed in its proper medium. It is in part an abstract meditation on the profusion of artificial objects in the sky, and makes effective use of radio chatter to convey their connections to the ground.

The dome can accommodate many types of imagery. The multi-screen performances of experimental cinema may be recreated and further developed in this space. The surface can be treated as a continuous projection area, or a sequence of concentric rings, or various geometric configurations. Despite the issues involved with audiences trying to watch events behind and above them (seats in domes are often tilted to compensate), the experience of dome projection becomes quite natural, to the point where standard cinema screens feel small by comparison. However, I will argue later that the dome is not a 'cinematic' medium *per se* precisely because of its immersive qualities, and attempts to make it so are unsatisfactory. Fulldome must be approached with full knowledge of its spatial potentials.

5 Antecedents of fulldome

Having said that fulldome is a new medium, there is of course an ancient history of architectural domes and their use as painted and decorated surfaces. This heritage is very important when considering the contemporary appeal of the dome, because domes have been used in special contexts

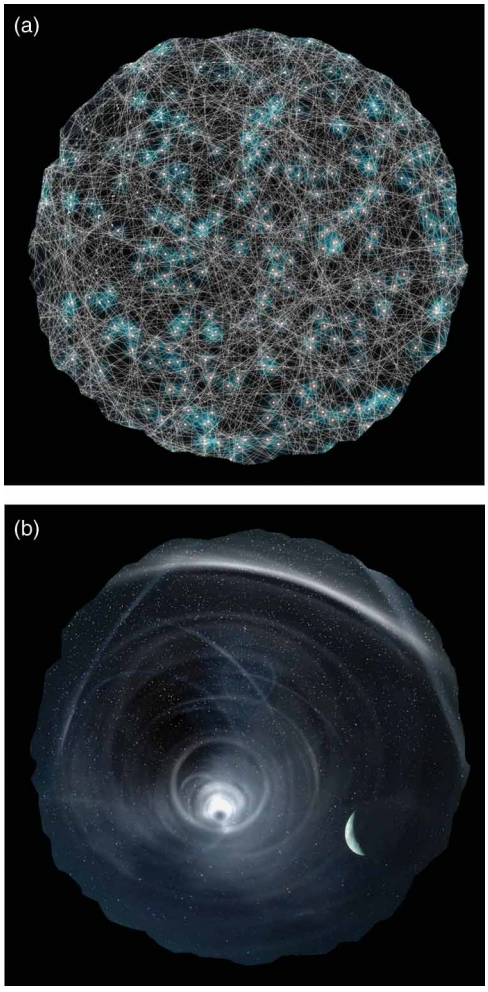

Figure 5. *Celestial Mechanics*, D. Scott Hessels and Gabriel Dunne, 2006.
Source: Reproduced by permission of Scott Hessels.

such as religious and funerary buildings. The history of domes extends beyond the true dome to the tents used by our nomadic ancestors. The dome's association with the sky, and heavenly scenes, seems to spring from a very deep-seated human urge to incorporate the cosmos into an architectonic form, and can be traced back as far as the earliest civilisations of the Near East.

Before there were true domes, cultures from Ireland to eastern Asia made corbelled domes, spanning spaces with stone vaults that approximated a dome-like shape. Many of these were tombs (or were used as such) and have survived into the present. One of the best examples in Britain is the chamber at Maeshowe in Orkney, part of the large megalithic complex that includes the famous village at Skara Brae and the standing stones at Stenness.

Built around 2800 BC, Maeshowe is an impressive 7.3 metre high earth-covered chambered cairn, with corbel vaults inside creating a large dome-like space. Its most intriguing feature is the orientation of its entrance passage which faces the setting sun at midwinter, allowing a shaft of light to enter the interior before it gradually fades. This light-symbolism is suggestive of a link between the sky and the earth, and echoes the midwinter sunrise alignment at Newgrange, the great Irish monument of similar age. Archaeologist Colin Richards views Maeshowe as a cosmological statement by the Neolithic inhabitants of Orkney, a means of linking their mundane world to the domain of the dead:

> *While always a visible aspect of the lived and worked landscape, Maeshowe also has a time as well as a place. Its passage is oriented towards the south-west, aligned towards the setting sun on the few days immediately before and after the winter solstice as it drops below the hills of Hoy … Throughout the year the interior is in perpetual darkness, there is no life-providing hearth within the central chamber; it is a residence of the dead. Then, at the heart of winter, with all its connotations of darkness and cold, the dying midwinter sun illuminates the interior of the passage grave (Richards 1996).*

Richards argues that the monument marks the passage of time with respect to the internment of the dead within a place that is both above and below ground. Also its construction embodies the local geology: made from rocks covered with natural boulder clay. Thus, the dome at Maeshowe could be seen as a local microcosm, an artificial cavern that reflects the order of the outer world.

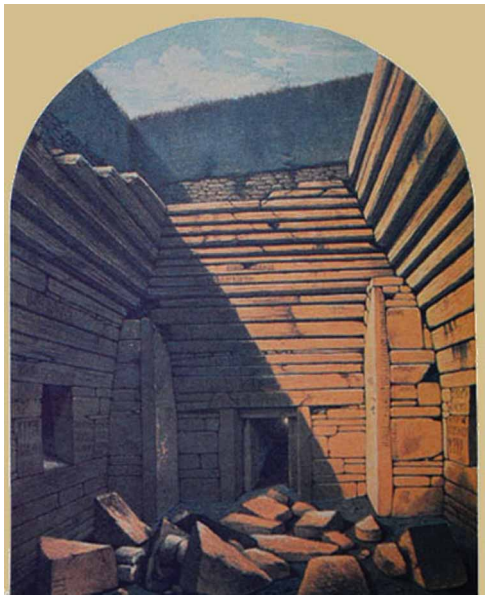

Figure 6. Maeshowe after excavation in 1861.
Source: Engraving by Gibb in James Farrer, 1862. *Notice of Runic Inscriptions Discovered During Recent Excavations in the Orkneys*, Edinburgh: Clark. Online at http://www.gutenberg.org/files/34816/34816-h/images/plate_002.jpg (Public Domain). [Accessed 2nd April 2012]

6 Domes and cave art

The dark chamber at Maeshowe recalls a cave, and it might be that artificial domes are deliberately evocative of these primordial sites of human habitation and ritual. There is a clear connection between caves and the development of image-making, as Lascaux and Altamira testify; these rich Magdalenian sites from 17,000 to 14,000 years ago are filled with a profusion of depictions, both abstract and naturalistic, and highly developed in their technique. I believe the key to understanding the modern appeal of the dome as an environment lies in these cave image-spaces, and in the process by which pictorial forms were executed in them.

As Wilhelm Wundt observed in 1916: 'The half darkness of caves is more appropriate than most interiors to arouse an after-image fantasy … our memory images are much more lively in darkness or twilight than in the day' (Wundt 1916, cited in Kubler 1987, pp. 77–78) There is a strong link between the recall of mental imagery and the use of caves and rock shelters as locations for early paintings. Paleolithic sites in Europe show evidence of returns to the same places over centuries, as if they retained a persistent attraction to the artists.

The South African anthropologist David Lewis-Williams, who has worked with artists among the San people, observed that cave art throughout the world contains similar basic marks. He links the repeated geometric forms—'grids, zigzags, dots, spirals, and catenary curves'—to entoptic phenomena: images generated internally by the human visual system that are not phosphenes (induced by stimulation of the eye). As a basic part of human perception, these entoptic images could be a universal factor in visual culture:

> *All these percepts are experienced as incandescent, shimmering, moving, rotating, and sometimes enlarging patterns; they also grade one into another and combine in a bewildering way (Kluver 1942: 176). Because they derive from the human nervous system, all people who enter certain altered states of consciousness, no matter what their cultural background, are liable to perceive them (Lewis-Williams and Dowson 1988, p. 214).*

Lewis-Williams speculated that the painted images on the walls of caves, in near-dark surroundings, was an externalisation of these internal images, based on research into entoptic imagery that found it could be 'projected' in suitable settings as a two-dimensional form.

> *Kluver … found, from his own experience, that both entoptic phenomena and iconic hallucinations seemed to be localised on the walls or the ceiling. … Such reports suggest that early people similarly experienced mental imagery and afterimages projected onto their surroundings. Their surroundings were thus already invested with 'pictures.' … these images, as they are projected onto a wall, attain their 'own free- floating existence, independent of scene or surface' (Lewis-Williams and Dowson 1988, p. 215).*

Figures 7. Maeshowe, Orkney, today.
Sources: Maes Howe today by Andy McLaughlin, Sept 4th 2011, by permission. (http://www.flickr.com/photos/mr_mclaughlin/6113819131/sizes/l/in/photostream/)

Figure 8. Chumash art on the walls of Painted Cave, above Santa Barbara, California.
Source: Doc Searls, 9 July 2009, by permission (http://www.flickr.com/photos/docsearls/3760974021/in/photostream/).

The cave might thus be compared to a kind of 'screen' on which internalised images could be fixed by painting and incising. Lewis-Williams's theory (which is far from uncontroversial in the anthropological field) could explain part of the attraction of the dome as a similar venue for projection of images, particularly when used for purely abstract animations. It is known that Jordan Belson and Stan Brakhage both tried to capture some of their 'mind's eye' experiences in the animations they created, and Brakhage had an interest in entoptic phenomena. As film theorist Edward S. Small notes of Brakhage's 'closed eye vision' images:

> *[My] particular position . . . is not to equate mental images with motion pictures, even metaphorically, but to contend that certain motion picture renditions of mental imagery are semiotically closer to special modes of mentation than are, say, linguistic sentences or mathematical formulae (Small 2002).*

The recent artwork *Continuum* by British artist Paul Grimmer has some continuities with entoptic imagery. It deploys a spatialised sound system optimised for dome acoustics. The animation consists of symmetrical figures moving in highly geometric patterns in the dome environment, and various human figures moving across the surface of the dome:

> *Continuum is an immersive Fulldome video work with 5.1 surround soundscape created specifically for immersive planetarium environments. The work is a meditation on notions of beauty, perfection and difference focusing on a body, physically and digitally modified and transformed. As the body moves in and out of focus, suspended, it is glimpsed, not seen, taken apart, re-ordered and replicated into new, exotic forms (Grimmer 2010).*

However, whilst a lot of rock art fits Lewis-Williams's concept of purely entoptic geometric forms, much of it is figurative and, in the case of Lascaux and other products of the Magdelanian culture, closely based on observation from life. Indeed, these caves derive much of their impact

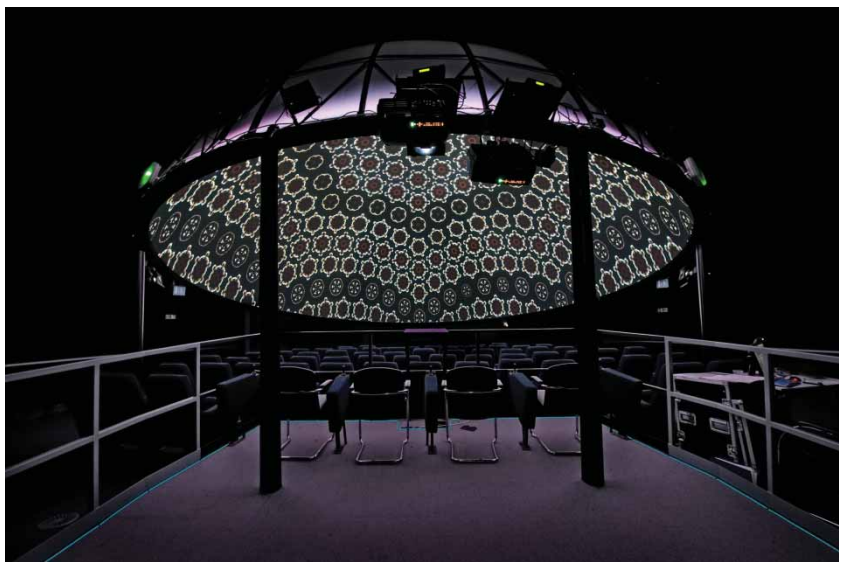

Figure 9. *Continuum* (Paul Grimmer, 2010) at the Newcastle Centre for Life.
Source: Image: Colin Davison, http://3.bp.blogspot.com/_dH3U9ulvWGM/TD87ELp5G-I/AAAAAAAAA5c/H7CPWkP979Q/s1600/continuum_dome_view1_1MB.jpg. (By permission)

from the sheer profusion of images at all angles, utilising even the most inaccessible corners for paintings and also taking advantage of contours in the rock to assist the outline and textures. Joseph Lyons sees this in terms of selecting a deliberately dramatic and ritually affective site for the paintings:

> *The places self-selected for these enduring works . . . were deep within the caves, in darkness that required flickering and smoky lights to be seen, in locations that demanded almost the effort one would need to enter another world . . . the works could be fully seen only . . . in the proper stance, participating as it were, in the full effect of a shadowed, flickering, shimmering, and unreal world (Lyons 1967).*

Several commentators have also noted the capturing of movement through multiple superimposed drawings, and the cinematic nature of the depiction (Noxon 1964, p. 26). Edward Wachtel experienced one of the lesser-known caves by lamplight (Lascaux is now lit by electricity) and confirmed the effects of motion produced by natural light sources. He drew attention to the 'integration of time into the viewing experience' and averred that this demonstrated how time and space were not separated in the Paleolithic worldview. The cave paintings showed that their concept of time was 'arranged in mythic terms, with causes and effects more unified; with their past, present and future more compressed' (Wachtel 1993, p. 140).

This reflection on *time* can be extended to the Fulldome space. In the planetarium, time can be represented by the motion of the planets and stars, and thus shifted into the distant past or future simply by the changing positions and orbits of these bodies. At its most basic, this is merely the changing of an abstract pattern across the 'sky' created by the dome; it does not invoke any other pictorial conventions. Change the imagery to a more human-centred and realistic subject, however, and the clash between cinematic convention and the dome space becomes highly apparent.

If the animators or film-makers decide to focus on a traditional narrative, then inevitably the activity clusters around the centre and front of the dome as if it were merely a large, curved movie screen. Time flows forwards (or sometimes backwards) towards the viewer and the rest of the dome merely hosts supporting material.

The alternative approach, more often used in abstract material that has a certain kinship with the stars of a planetarium, is for time to go *around* and *above* the viewer and for their eye to be guided up into the centre of the dome. To me this is a far more genuine use of the space to its fullest advantage, as it invokes the aspect of height, and distance, and can make the space seem far larger than it actually is. The dome might also encourage eidetic after-images in viewers, due to the contrast between dark and light, and the rapid movement of images around both forward and peripheral vision.

If the cave represents the start of cinematic imagery, and marks the beginning of the immersive experience that can be so effective in the dome, then it is quite possible that the incorporation of time and interactive elements in art has a far longer history than many commentators on 'new media' might realise. This is why a discussion of eidetic and entoptic images in relation to the production of cave art is so important for understanding the basic appeal of fulldome images as well.

As a final echo of the cave inside the dome, several researchers have discovered marks at Lascaux that seem to be constellations, including the stars of Taurus just behind a depiction of a bull. The cave thus becomes a microcosm and leads directly to the planetarium.

One more theory on Paleolithic imagery should be raised here: the idea of the natural *camera obscura*. The lens-based *camera obscura* is one of the essential tools of Renaissance art, a live demonstration of the perspectival theory and the starting point of the technologies of photography and film-making. However, the effects of a *camera obscura* were known long before the sixteenth century; if conditions were right, then any dark space with a suitable aperture to let in

Digital Creativity, Vol. 23, No. 1

Figure 10. Gatton's reconstruction of a Paleolithic 'camera obscura'.
Source: http://www.paleo-camera.com/images/paleocameraPC1.jpg, reproduced by permission of Matt Gatton.

bright sunlight might throw the image from outdoors into the room. The artist and researcher Matt Gatton has proposed that this might have occurred in the tents and huts used by Paleolithic peoples, and demonstrated that small holes into these otherwise dark spaces can act as *camera obscuras* when the outside conditions are right:

> *Coincidentally projected images would seem almost randomly granted, though they are the result of optical physics acting in a predictable fashion. . . .To be in a room-size camera and behold the beauty and wonder of the objects and beings of the outside world floating ephemerally on every surface, people included, provokes deep spiritual questions (Gatton 2010, p. 5).*

Gatton supports his theory with the multiple movement-based drawings and paintings of the Paleolithic caves. It has been said that these were sketched from life, yet the superimposition of moving forms is almost photographic. Gatton's experiments show that sketches could be made on bark or other surfaces held under a projection of an outside image (e.g. a horse or a mammoth), with its changes in stance recorded by a several quick drawings. Presumably these drawings were later transposed to the walls of the caves. At the very least, Gatton offers a 'long history' of projection and projected imagery.

7 The architectural dome as image-space

The earliest architectural remains are found in the Near East. The recently excavated site at Gobekli Tepi in Anatolia shows evidence of circular temple structures built around 11,000 BC as well as fine sculptures and reliefs on large T-shaped monoliths, which could have been roof supports. The first evidence of actual domes appears much later; K.A.C. Creswell points to an Assyrian plaque discovered by Layard at the palace of Sennacherib at Nineveh around 700 BC that shows domed structures. Creswell believed that the vernacular architecture of the Near East was the most likely origin of the dome (Creswell 1915). Of course, the corbelled roofs at Maeshowe and elsewhere already existed by this time.

There is a definite connection between domes and funerary architecture, and with certain kinds of temples, but only in the Roman period does this become established in the West with the construction of several impressive buildings culminating in the Pantheon in Rome, by the Emperor Hadrian around 124–128 AD. The Persians also developed the dome as a feature of royal architecture and a widespread medieval legend described the tower of Chosroes (Khusrau II) as a huge mechanical planetarium.

This was clearly influenced by Seneca's description of Nero's famous Golden House,

Figure 11. Interior of the Pantheon, eighteenth century, by Giovanni Paolo Panini.
Source: Public domain on Wikimedia, available from: http://en.wikipedia.org/wiki/File:Pantheon-panini.jpg.

which not only boasted a revolving dining room but also a movable ceiling that would change with every course. As Lehmann notes: 'It is also clear that the changing aspects of this cosmic dome revealed heavenly bodies and that it constituted a kind of planetarium' (Lehmann 1945, p. 22). After Archimedes invented the mechanical planetarium or *microcosmos*, the Romans are known to have built models of their own. The cosmos also became a subject for decorative art, and Lehmann observes how the convention of painting cosmic scenes on ceilings and domes developed from Etruscan tombs into the Roman period. This continued on into Christian times:

> *In both the pagan and Christian worlds, the manifold visions of the dome of heaven, with their symbolism in canopies, figures, and structural forms, with the projections of heaven on*

Digital Creativity, Vol. 23, No. 1

> *ceilings, often coupled with an actual or supposed opening in the sky, all reflect the basic experience of man in visualizing the physical as well as the transcendental celestial realm. It is evidently because of this ever increasing tradition of heavenly visions on ceilings that* coelum *[heaven] became a common term for roof or ceiling in late antique speech (Lehmann 1945, p. 25).*

The Pantheon is the greatest surviving example of the Roman dome tradition, and incorporates the cosmic motion into its very structure. As the name 'Pan-theon' indicates, it was a temple to 'all gods' and their statues were illuminated by the disc of sunlight that shines through the *oculus*, the central hole in the dome, and moves gradually around the interior. As William Loerke says:

> *the major visual experience in the Rotunda, apparent to anyone immediately upon entry, whether or not he knows anything about Roman temples, Roman religion, or Roman history, is the single shaft of sunlight slowly moving through the space. The Rotunda isolates the sun's motion. It has always offered its visitors a palpable experience of celestial motion (Loerke 1990, p. 41).*

The largest freestanding concrete dome in the world until modern times, the Pantheon incorporated references to celestial globes, the twenty-eight-day cycle of the moon and the sixteen directional divisions of the sky (McEwen 1993, p. 63). It probably also included a painted zodiac around the rim of the *oculus* too (Joost-Gaugier 1998, p. 35). Loerke also links the Pantheon to the idea of the *templum mundi*, a sacred cosmology that saw the heavens as a kind of temple in themselves and related their movement back to temple architecture.

The Pantheon's survival over 1,900 years is miraculous, and probably attributable to the awesome solar spectacle that made it central to the Roman state religion. When Christianity became the official faith, most temples were abandoned, desecrated or plundered for their building materials, but the Pantheon was converted into a church in 609 AD and remains almost as it was in Roman times.

Domes of various types were incorporated into early Christian architecture and decorated with mosaics; they later became a feature of Islamic sacred buildings too, hence the famous Dome of the Rock in Jerusalem, also with mosaic decorations, and examples in Egypt, Iraq and further east. In Buddhism the dome was an essential element of the *stupa*, a memorial structure which was often made on a monumental scale as at Sanchi in Madhya Pradesh in India. After the great cathedral of Hagia Sophia was completed in Constantinople with the largest dome since the Pantheon, Eastern Orthodox churches from Greece to Russia included domes in their construction.

However, in the West, the development of Gothic architecture favoured polygonal towers and spires over domes during medieval times. Instead, medieval cathedrals created effects of light and colour by using increasingly complex windows filled with stained glass, and especially the rose window which was a development of the *oculus* of earlier buildings (Cowan 2005, p. 41). Only during the Renaissance did the dome come back into fashion, as building technologies improved to the point where Brunelleschi could design the Duomo of the new cathedral in Florence, Santa Maria del Fiore, built between 1446 and 1461.

Brunelleschi was an architect, inventor and artist in true Renaissance style: besides designing the dome's structure, he developed new hoists and investigated Vitruvius's Roman texts for clues as to the mechanisms used for the Pantheon. He also (perhaps not coincidentally) created stage machinery for use in religious dramas where angels literally flew and descended in globes from the heavens with lighting and sound effects, at least according to Vasari's later descriptions (Larson 1957). As in Roman times, it was common for architects to be involved in stage entertainments and the development of mechanical devices.

Brunelleschi has a special place in the history of art for his invention—or perhaps codifica-

Figure 12. Pierre Mignard, fresco in the cupola of the church of Val-de-Grace, mid-seventeenth century.
Source: Myrabella/Wikimedia Commons/CC-BY-SA-3.0: http://commons.wikimedia.org/wiki/File:Coupole_Val-de-Grace_fresque_Pierre_Mignard.jpg. (Creative Commons licence)

tion—of single-point perspective, giving a dramatic precision to the previously variable perspectives used in art (Winston 1987, p. 199). This enabled new expressions of realism in art executed on flat canvases, and developed the optical tools that would lead to the camera and screen. But perspective was also important for dome imagery because it offered new ways of presenting the dome as an illusionistic space, especially where the heavenly imagery could be developed into a kind of stage of its own. The illusionistic effects on domes and ceilings were known as *trompe l'oeil*—'triumph of the eye'—and presented vistas that depended on the viewer's distance, and suspension of belief.

A French painter of the seventeenth century, Abraham Bosse, who was a founder member of the Academie, produced a treatise on the proper perspective for domes, his *Moyen universel de pratiquer la perspective sur les tableaux ou surfaces irregulieres* in 1663 (Goldstein 1965, p. 241). Following the ideal of presenting images as if from nature, Bosse used single-point perspective, represented as lines converging on a single central from all points of the artwork, forming a pyramid. In standard artworks, the plane surface of the painting intersects this pyramid and the points of the image are recorded on the canvas. This idea was the basis for perspectival geometry.

Bosse took this concept and rotated it from the horizontal to the vertical, such that the viewer was standing at the centre of the room, looking up. Instead of the canvas providing a window onto a scene, the ceiling became a transparent floor into

Digital Creativity, Vol. 23, No. 1

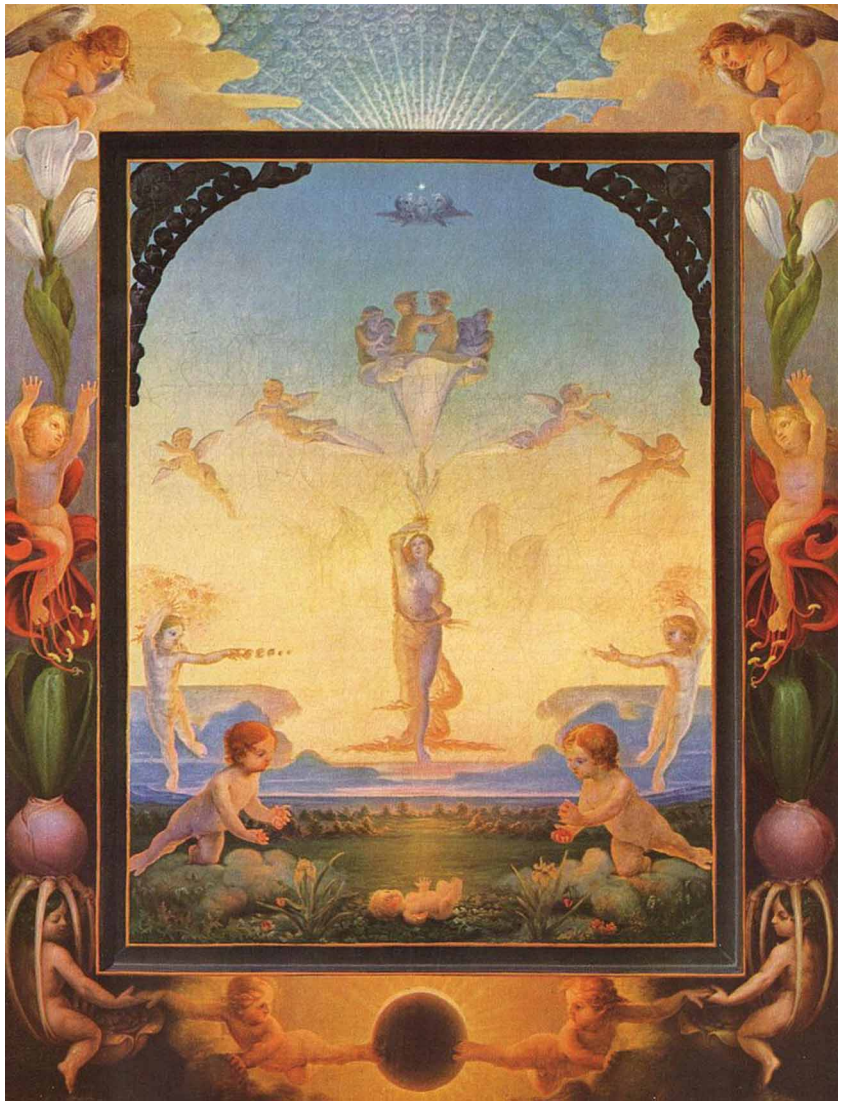

Figure 13. Philipp Otto Runge, *Der Morgen* ('Morning'), the only completed picture from the 'Times of Day' sequence. *Source*: From The Yorck Project, Wikimedia Commons, http://en.wikipedia.org/wiki/File:Philipp_Otto_Runge_001.jpg. (Public domain)

an upward projection that usually opened upwards into the heavens (in a way not dissimilar to the *oculus* in the Pantheon). Figures were foreshortened and usually sat on clouds or architectural elements that carried them up to dizzying heights; this worked for both Classical mythological scenes and Biblical ones, especially visions of the Second Coming and similarly celestial affairs. The theories enabled the famous *trompe l'oeil* effects of Baroque ceilings to be realised, and domes could then utilise a more realistic approach to perspective (Goldstein 1965, pp. 241–243).

The French artist Pierre Mignard deployed these techniques in his work on the dome at the Parisian church of Val-de-Grace in 1663–1665:

> *The painted surface depicts a celestial glory and is organized in three continuous, concentric rings: the first is crowded with saints, martyrs, and Old Testament figures … All the figures were designed for a view from below and foreshortening is consistent with relative position i.e., figures on the upper surfaces are more strongly foreshortened. … Except for the Trinity, the spatial setting of all figures is perceived as immediately 'beyond' that part of the circumference on which they were fashioned; that is to say, the surface is 'opened up' illusionistically, … Immediately above the Trinity one is confronted with an infinite space (Goldstein 1965, p. 253).*

This effect is of course heightened by the physical distance of the dome from the viewer, below in the main body of the church, and is intended to create the illusion that the dome is a lens into the Biblical heaven, a sort of sacred periscope.

Secular scenes could be depicted on domes and these usually included references to the Zodiac and the increasingly sophisticated picture of the night sky that emerged throughout the seventeenth century after the invention of the telescope. New constellations were being named and greater distances probed; and the model of the universe shifted from Aristotle's geocentric concept to the heliocentric one advocated by Copernicus and Galileo (although many ancient thinkers had also proposed it). Mechanical orreries were built to illustrate the Solar System.

Some of these early planetaria were on a surprisingly grand scale, like the famous Gottorp Globe of 1664 made by Adam Olearius for the Prince of Schleswig-Gottorf, which was later presented to Tsar Peter the Great in 1714. The 3.1 metre sphere was painted with the terrestrial globe on the exterior, whilst the interior—which was large enough for ten people to sit inside—was lined with the constellations and known stars. Powered by water, the globe would slowly revolve around its occupants. It was moved to Moscow around 1715, and Peter would often sit in it and reflect on the heavens:

> *Once, sitting together with Blumentrost in the globe, Peter said: 'we are now in a great world, this world is in us, thus worlds are in the world' (Bagrow 1949, p. 95).*

From this point, the evolution of the modern planetarium can be charted via panoramas and other circular spaces, the Victorian fashion for room-sized *camera obscuras* and panopticons, and the development of slideshows, along with increasingly accurate models and photographs of celestial objects. However, at this point I want to divert towards the artistic understanding of the dome and some possible reasons for its attraction as a space for art, as well as science. The artistic input into the domes of churches and palaces is obvious, but why should a space that evolved primarily for science education become a venue for art?

Part of the answer, I think, can be glimpsed in some of the projects by the visionary French Revolutionary architect Louis-Etienne Boullée. Active during the greatest ferment of Revolutionary ideals in the 1780s, Boullée planned a series of titanic monuments to various inspirational figures from mythology and history, along with designs for vast libraries and public buildings. Perhaps the most striking and audacious was the 'Cenotaph to Newton', a stone sphere over a hundred metres high (inferred from the scale of figures on his plans).

Boullée intended to capture the cosmic span of Newton's ideas by leaving the interior of the sphere almost empty apart from an extraordinary device: he would have holes made in the surface to match the arrangement of the stars, so that in the daytime the dark interior would be lit by a 'starry sky'. At night, conversely, Boullée proposed a huge illuminated astrolabe in the centre of the dome, presumably in motion. Despite the quasi-scientific trappings, however, it is obvious that Boullee was moved by the numinous spatial qualities of the dome and wanted to make full artistic use of them, and the properties of light and shade that seem to be an essential feature of this space right back to the caves.

Boullee is right to invoke the sublime, which has long been linked to a movement of self-transcendence that leaves behind the body and its bonds … 'By using your divine system, Newton, to create the sepulchral lamp that lights thy tomb, it seems that I have made myself sublime' (Harries 2002, p. 156).

8 Colour music and the 'total work of art'

Whilst Boullee is inextricably connected to the Enlightenment belief in the supremacy of reason and Newtonian knowledge, an evocation of the sublime also underpins a Romantic vision of the unity of the arts, which I think is also fundamental to the idea of what 'fulldome' can achieve. Though the Romantics reacted against the cold universe of the Enlightened age—best summed in Blake's famous drawing of the Ancient of Days measuring out the universe, with his words 'May God us keep / From Single vision and Newtons sleep'—there was nevertheless an interest in the science underpinning the arts.

This takes us away from domes *per se* towards the area of colour-music and the *clavicin oculaire*, the colour harpsichord invented by the French Jesuit Betrand Castel in 1742 that displayed different shades in illuminated windows as the keyboard was played. Numerous composers wanted to embody the ancient idea of tonal correspondences with colours (ironically updated by Newton's separation of white light into colours through a prism). Progressively advanced 'colour organs' were created during the nineteenth and twentieth centuries.

The German Romantic artist Philipp Otto Runge had a vision of reuniting arts and sciences that he pursued throughout his short life (1777–1810) and his writings inspired similar efforts amongst his peers. Though best known today for his colour-studies, he also inclined towards synasthesia, the ability of associating images and sounds, and proposed a *Gesamtkunstwerk* or a work of total art, long before Wagner made it a reality (Bisanz 1988, p. 81).

To achieve this, he wanted to construct a special building where his cycle of paintings 'Times of the Day' would be displayed in conjunction with specially composed music and poetry. His contemporaries were said to be amazed that 'the relationship between mathematics, music, and colors is not articulated as an idea but given visible form in large flowers, figures, and lines' (Domling 1994, pp. 3–9). Clearly this building would be a space in which the performative and meditative aspects of visual and musical art could be experienced:

The 'building,' an-imaginary-space for experience, is more precisely a space for meditation and contemplation of times, the cosmos and the universe. ('In every completed work of art,' Runge once wrote, 'we can feel our most intimate relationship with the universe.') (Domling 1994, p. 7).

This aspect of the dome deserves more attention: as well as being a representation of 'outer' space it can also be seen as an analogue for one's interior space too. This touches on the entoptic imagery of the caves and also takes in the immersive, all-encompassing performance that occurs within the dome. Is this part of its attraction, that it enables us to go inside ourselves and sit in a special environment that reflects back into our self in some way? Psychologists should examine this further as the concept of an all-encompassing 'art space' is clearly a longstanding fascination amongst some artists.

Mention of synathesia is also important, since this condition (or even the aspiration towards it) has impelled some artists and musicians to find equivalences between sound and images. One of the best-known exponents was the Russian composer Alexander Scriabin, who was so concerned with including light and colour in his music that he created a score for a 'light keyboard', *Tastiera per luce*, for his orchestral piece *Prometheus* that premiered in 1911.

The idea of the Luce *was quite simple: colour was to change in unison with tonal dynamics in accord with a system of colour-tonal associ-*

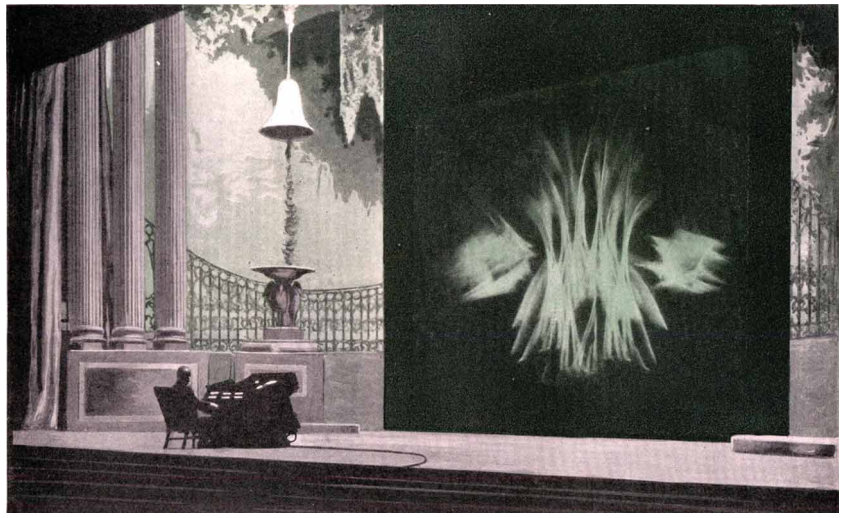

Figure 14. Thomas Wilfred playing the Clavilux in 1924.
Source: *Popular Mechanics*, April 1924. (This work is now in the public domain)

> *ations suggested by the composer (Galeyev 1988, p. 385).*

However the actual machine broke down before the initial Moscow performance, and only in 1915 was *Prometheus* first performed with coloured lighting at Carnegie Hall. The light-machine score was lost until its rediscovery late in the twentieth century but has been reconstructed for recent performances.

Scriabin was very serious in his wish to converge music and colour, and thereby achieve the *gesamtkunstwerk*; he did not wish to be remembered merely as a 'musician'. He also wanted to go beyond the personal associations of synasthesia (most syansthetes experience their connected senses in very specific ways) and achieve a universal system for colour-music. To this end he proposed a work called *Mysterium* that occupied him in the last decade of his life (Garcia n.d.). Linking Theosophical mysticism (an important strand in early twentieth-century Russian art) with a religious ceremony, the *Mysterium* was the culmination of a seven-day performance called the Preliminary Action:

> *envisioned as an all–encompassing performance spectacle, embracing music, sound, and non–human noises; color and light (including the seven sunsets and sunrises); dance; processions; eye motions, mime, and gestures; fires, incense, perfumes, and pungent odors; tastes, caresses, pain and other tactile experiences; and various theatrical effects and actions—all interspersed with poetic declamations symbolically recounting the whole of evolutionary history (Cross 1975).*

The site was significant too: a semi-circular temple with a reflective pool to make it complete circle, with a stage for performances and Scriabin himself at the centre of it all, seated at his grand piano! In fact, Scriabin attached various apocalyptic prophecies to this seven-day performance, looking forward to a transformative cataclysm that would occur at the culmination of the *Mysterium*. Alas, all that remains is the score for the initial part of the Preliminary Action, which was completed and recorded by Russian composer Alexander Nemtin in the 1970s. Scriabin himself died in 1915.

Whilst the Russian Revolution initially encouraged the fusion of art forms, the later artistic conservatism of the Soviet republic marginalised these ideas, although the Leningrad artist G.I.

Digital Creativity, Vol. 23, No. 1

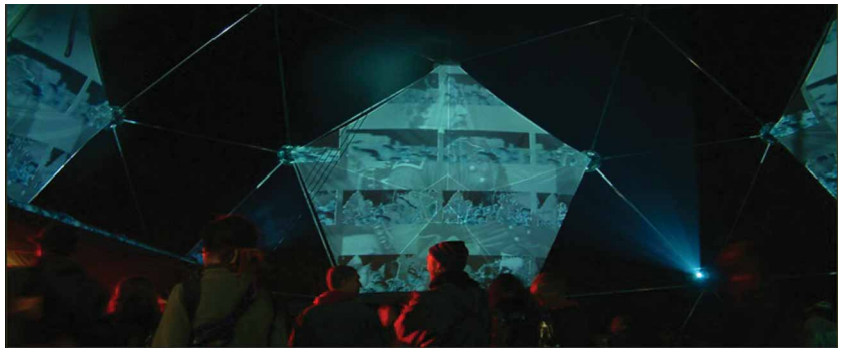

Figure 15. Gaianova, Pentavision dome.
Source: Gaianova (2012), reproduced by permission.

Gidoni wrote a book on *The Art of Light and Colour* around 1933, and proposed a huge spherical hall for audio-visual performances as a monument to the Revolution in 1928 (Galeyev 1988, p. 387). Later, Bulat M. Galyev maintained an interest in Scriabin's work throughout the 1960s and 1970s, and staged a number of light machine performances that helped the rediscovery of Scriabin's multimedia works.

Scriabin's true successors were the pioneers of Abstract Animation—Oskar Fischinger, Mary Ellen Bute, Len Lye and their contemporaries—who realised the potential for using animated sequences on film to link music and imagery. Their abstract forms were strongly influenced by Russian Constructivism and the arts-science interest of the Bauhaus; Mary Ellen Bute in particular was a student of the mathematical music theories of Joseph Schillinger. Bute is also notable for using an oscilloscope to create musical animations, a direct precursor to computer graphics (Moritz 1996).

The Danish-born pioneer of visual music, Thomas Wilfred, not only designed and built numerous examples of his Clavilux abstract-music-image player, but also conceived of an 'Art Institute of Light' that would be a purpose-built structure for visual music. The Institute was eventually created at Grand Central Palace, 480 Lexington Avenue in New York with an impressive array of projectors and a recital hall seating seventy-five people. Wilfred referred to his particular output as 'lumia'.

Until his death in 1968, Wilfred ceaselessly promoted the idea of lumia as an 'eighth art form' and continued to construct light machines. Though extensively acknowledged in histories of this medium, one feels that Wilfred would benefit from more attention, as he seems to have been one of the more successful exponents of this area. Wilfred had a clear conception of the aesthetic behind lumia which he expounded in an article written in 1947:

> *The lumia artist conceives his idea as a three-dimensional drama unfolding in infinite space. In order to share his vision with others he must materialize it. This he may do by executing it as a two-dimensional sequence, projected on a flat white screen … But the original vision—the three-dimensional drama in space—is constantly before him and he strives to … perform it so convincingly in a spatial way that the … the spectator imagines he is witnessing a radiant drama in deep space (Wilfred 1947, p. 252).*

Many of these experimentalists were aware of contemporary developments in cinema which aimed to increase the immersive effect of movies. For instance, in 1937 Henri Chretien's Hypergonar Lens projected a 60 metre by 10 metre panorama onto a concave wall at the Inter-

national Exposition in Paris. The American inventor Fred Waller projected a composite of stills onto a curved screen at the New York World's Fair in 1939, as part of his quest to fill the human peripheral vision with imagery. 'He concluded that in order to fill the field of human peripheral vision, he would need a screen that was the width of an entire city block' (Belton 2004, p. 277).

After World War II, immersive and multi-screen environments became more widespread. Charles and Ray Eames worked on several installations during the 1950s, the most famous of which was the film *Glimpses of the USA* which ran during the 1959 American National Exhibition in Moscow. Produced using multiple combinations of stock and specially shot footage, the film presented a kaleidoscopic view of America on a vast scale. The Eameses wanted to break the 'discontinuity' they perceived between the various arts and life, and also develop an information space that could deliver image data in new ways (Colomina 2001, p. 16). *Glimpses* embodied these ideas in a new format that drew on the Eameses' experience in multi-format design and architecture:

> *The Eameses were selfconsciously architects of a new kind of space. The film breaks with the fixed perspectival view of the world. In fact, we find ourselves in a space that can only be apprehended with the high technology of telescopes, zoom lenses, airplanes, nightvision cameras, and so on, and where there is no privileged point of view (Colomina 2001, p. 11).*

The delivery of multi-screen information became ever-more urgent in the development of Cold War technologies; computer graphics and imagery were spurred by the need for rapid detection and response to nuclear strikes, which in turn led to the decentralised model of the Internet. Around this time, two American artists approached the dome space with similar intentions but different results: Jordan Belson and Stan Vanderbeek.

Abstract animator Jordan Belson developed a series of multimedia concerts at the Morrison Planetarium in San Francisco for three years from 1957, after being invited by composer Henry Jacobs to develop visual imagery for pieces commissioned for these events. Belson was already pushing towards a form of art that captured the mind's mental images; as he later said to Gene Youngblood: 'The mind has produced these images and has made the equipment to produce them physically. In a way it's a projection of what's going on inside, phenomena thrown out by the consciousness, which we are then able to look at' (Small 2002, p. 21).

In the dome space, given access to a panoply of projectors and starfield equipment, Belson was also aware that the old concept of a stage with a proscenium arch, or indeed a flat forward-mounted screen, should be broken down. In this he was anticipated by 'Total Theatre' movement which, from the start of the twentieth century, demanded new forms of theatrical space to overcome the separation of audience and action. The Polish theatre director Zygmunt Tonecki summed up their aims in 1936:

> *Just as Cubism broke down and expanded the conception of space in Renaissance painting (perspective), so the architectonic theater of today, that is to say, the Theatre of Space, wants to destroy and abolish the two dimensional stage. [The] conventional theatre wants to contemplate reality through a stage opening. The Theatre of Space seeks to erase this artificial form; it transports the stage into the auditorium and by this means renders the theatre active (Aronson 1981, p.496).*

But Belson then brought this to bear on projected imagery. He was certain the dome space was a better venue for his abstract animations, which he saw as being closer to theatrical performance than to 'film' as such:

> *As to the ultimate significance of Vortex, Belson believes it to be, perhaps, a prefiguration of the theater of the future. Film, to him, is simply a transitional form between conventional theater and whatever theater will be in the future; he does not regard Vortex as having much real connection with film: it com-*

> *poses in three dimensions, and produces a greater illusion of stereoscopic reality than any obtainable with film (Polt and Sandall 1961, pp. 36–7)*

Like so many of these collaborations, however, the Vortex concerts were dependent on the continuing support of the host institution. Around 1960 the Morrison Planetarium decided to discontinue these events, though Belson went on to do other Vortex-type performances. The concept was probably influential on the complex light shows staged by Californian bands in the later 1960s.

The Pepsi-Cola Pavilion at Expo '70 at Osaka could be viewed as the lineal descendent of the Vortex. The group Experiments in Art and Technology (EAT), suspended a highly reflective 90-foot mylar dome within larger steel structure. Within the dome, a system of lasers and lights created intense abstract images and various responsive cybernetic sculptures moved around (Herrmann 1973). Here was Gordon Pask's 'aesthetically potent environment' brought to life, and here too the dreams of Scriabin, Wilfred and Bute were realised, after a fashion.

Since that time, an inter-related stream of live light performances, musical spectacles on vast scales, and the development of VJ-ing (by Video DJs) during the 1990s–2000s have all drawn on the heritage of the multiformat sound-and-light projections. It is no surprise, then, that VJs have enthusiastically embraced the dome as an extension of their current work, and are in fact amongst the foremost developers of fulldome content.

GaiaNova, based in London, are a good example of this process: drawing on their practice as VJ artists and organisers of large outdoor multi-screen performances in geodesic domes, they have moved towards true dome projection as a way of unifying their content and extending the imagery they currently produce. They have become very active within Fulldome UK and were instrumental in setting up the show at Birmingham Thinktank in 2011.

Using live video mixing hardware and software that would have astounded the Abstract Animators, VJs have created projection systems that can adapt multi-image output to match the geometry of existing rooms and spaces. It is proposed to modify such servers to dome projection, such that they could automatically compensate for different dome sizes and mesh images in real time. This is currently the province of large fixed domes, but if it becomes possible then live performers in all kinds of venues could take advantage of the dome as a projection space. At present, all fixed dome installations are bespoke and dome animations have to be laboriously re-rendered to match, but an adaptable image-server would solve many of these problems.

The generally recognised prophet of the multimedia dome is of course Stan Vanderbeek, whose memory is undergoing something of a renaissance at present following a retrospective in 2008 at Guild and Greyshkul in New York, and a recent show of his works at the MIT List Visual Arts Centre (Smee 2011). Vanderbeek was an experimental animator who was highly prescient about computer imagery and communications in general; he collaborated with Bell Labs and with the Center for Advanced Visual Studies at MIT, and produced an early work of fax art in 1970. But the iconic Vanderbeek production is of course his Moviedrome of 1964, of which he built a large prototype at Stony Point in New York.

Whilst Belson made use of an existing planetarium, Vanderbeek intended from the start that the Moviedrome should embody the new approach to spatial imagery by bringing together multiple types of media: he appealed to supporters to donate discarded projectors, cameras, optical equipment, sound production and amplifiers and visual and audio source material. Like Belson, he aimed to disrupt the tyranny of the single-view screen, but his understanding of the media was closer to Marshall McLuhan and contemporary media theorists. He wanted to make people aware of the multiple mediums at work around them, and was attuned (so to speak) to the rise of satellite communication and what would eventually become the Internet. He foresaw a network of connected Moviedromes around the planet, delivering multiple channels of sound and

imagery of local and global import, with people walking in and lying down to take in the 'halo' of media around their heads. In one interview he referred to 'technology as an amplifier for the human imagination' (Durniak 1970, p. 80). Vanderbeek summed up his aims for the dome succinctly:

> *My particular work deals with the building of a prototype-cineman-space-stage … a magic theatre (called a Movie-Drome) in which the audience will ultimately be able to control a considerable amount of the audio-visual presentation (the audience lies down at the outer edge of the dome so that the field of view for each person is the dome-screen). . . . In theatres of this dome type I envision the future simplified image storage and retrieval systems, not to mention new image and graphic generating techniques (via computer and video-tape . . .) at which an artist will 'perform' an image concept by instant selection plus image interplay … this could also be an 'information concert' (Vanderbeek 1969).*

9 Conclusion

For all our advances in technology, we are really standing in a similar place to the one Vanderbeek perceived in 1970. Whilst our flat screens have become larger, even stereoscopic, we have not moved into a fundamentally new relation with images and data sources as he suggested we might, and as Belson anticipated in the 1950s. The development of fulldome might conceivably change this; indeed, it is beginning to change the relationship of viewers to the image, as more people discover that planetaria and portable domes can act as gateways into immersive environments quite unlike anything seen previously.

All the dome-related concepts covered in this article suggest new relationships with space, and spatial imagery, but another thread that runs through it is that the dome can also represent our 'inner space'. I do not mean that it is attempting to model or replicate what goes on in our heads, but rather it suggests a kind of reflective analogy, like the one perceived by Peter the Great in the Gottorp Globe when he referred to 'worlds within worlds'. Clearly, Belson understood the Vortex as a 'head space' akin to the imagery seen in his mind, and Scriabin's attempts to externalise synaesthetic appreciation of the world led to his multimedia performances. The reflective mylar dome in the Pepsi Pavilion, throwing the images of participants back on themselves, is the ultimate manifestation of this idea. Oliver Grau, in his brief history of VR from Pompeii to Char Davies's *Osmose*, considered that the attractions of the immersive medium are something quite primal:

> *Maybe we are regaining a relation to the image that reaches far back into precivilized history, giving it a power that transcends a psychic as well as physical boundaries and enables us to regress, leading to an ecstatic symbiosis of onlooker and image (Grau 1999, p. 370).*

The research into entoptic, eidetic and mental imagery in terms of the cave artists seems to resonate with these concepts, though of course their motivations and sensations must remain unknown to us. All we may infer is that the ghosts of motion and immersion have a very long history and perhaps helped shape us as humans.

What we have in fulldome art is the convergence of available technologies with the knowledge of techniques (including a widespread use of 3-D software and its more general deployment across the graphic arts), and the artistic aspiration to utilise them in a new way.

My aim in this article has been to show that the dome as heavenly vault and decorated surface is an ancient part of human perceptual experience, but in the modern era it has become a digital environment where the old dream of unifying visual and auditory art forms can take place. It is not simply a highly curved movie screen; the encompassing space of the dome and its essential element of height take it into a different area of activity. Although we can use tools developed for cinematic production in the dome, to make best use of it one has to understand its peculiar properties and approach it as a space in its own right.

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